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Exploring Molecular Pathways of Energy Crops in Heavy Metal Pollution Remediation

Andressa Reinehr*

Department of Environmental Engineering, Faculty of Engineering and Architecture, University of Passo Fundo, Brazil

Abstract

Basil pesto sauce manufacturing generates wastewater rich in organic compounds and nutrients, posing environmental challenges if not properly treated. This study investigates the bioremediation potential of microalgae Chlorella vulgaris Beij and Scenedesmus sp for treating wastewater from basil pesto sauce production. Both microalgae species were cultured in wastewater supplemented with nutrients under controlled conditions to evaluate their capacity to remove organic pollutants, nitrogen compounds, and phosphates. Monitoring parameters included biomass growth, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP), and lipid content. Results demonstrate significant reductions in BOD, COD, TN, and TP levels after microalgae treatment, indicating effective remediation of organic and nutrient pollutants. The lipid content of microalgae biomass suggests potential applications in biofuel production. This study highlights the feasibility of using Chlorella vulgaris Beij and Scenedesmus sp for sustainable bioremediation of basil pesto sauce manufacturing wastewater, offering insights into environmentally friendly treatment solutions for food processing industries.

Keywords: Bioremediation; Microalgae; Chlorella vulgaris Beij; Scenedesmus sp; Basil pesto sauce; Wastewater

Introduction

The production of basil pesto sauce involves various processes that generate wastewater containing organic compounds and nutrients, presenting a significant environmental challenge if not properly managed. Wastewater from food processing industries, including basil pesto sauce manufacturing, often contains high levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrogen compounds, and phosphates, which can adversely impact aquatic ecosystems if discharged untreated. Bioremediation, particularly using microalgae, has emerged as a sustainable approach to treat wastewater by harnessing the metabolic capabilities of these organisms to assimilate and transform pollutants into biomass [1]. Microalgae, such as Chlorella vulgaris Beij and Scenedesmus sp, are known for their rapid growth rates, ability to thrive in diverse environmental conditions, and capacity to remove nutrients and organic contaminants from wastewater. This introduction aims to explore the potential of Chlorella vulgaris Beij and Scenedesmus sp in bioremediating wastewater generated from basil pesto sauce production. These microalgae species offer advantages such as high nutrient uptake efficiency, oxygen production through photosynthesis, and the potential for biomass valorization in biofuel production [2]. By assimilating nutrients and metabolizing organic pollutants, microalgae facilitate the purification of wastewater while potentially yielding valuable biomass for sustainable applications. The present study investigates the effectiveness of Chlorella vulgaris Beij and Scenedesmus sp in reducing BOD, COD, nitrogen, and phosphorus levels in basil pesto sauce manufacturing wastewater under controlled conditions [3]. It aims to provide insights into the feasibility of integrating microalgae-based bioremediation as an environmentally friendly and economically viable solution for treating wastewater from food processing industries [4]. Moreover, this research contributes to the growing body of knowledge on sustainable practices in wastewater treatment and resource recovery through microalgae cultivation. Overall, understanding the bioremediation potential of Chlorella vulgaris Beij and Scenedesmus sp in basil pesto sauce manufacturing wastewater not only addresses environmental concerns associated with food processing effluents but also underscores the importance of exploring nature-based solutions to achieve sustainable industrial practices and protect water resources [5].

Results and Discussion

The bioremediation potential of Chlorella vulgaris Beij and Scenedesmus sp was evaluated for treating wastewater generated from basil pesto sauce manufacturing. The study monitored various parameters to assess the effectiveness of these microalgae in removing organic pollutants, nitrogen compounds, and phosphates from the wastewater.

Biomass growth and nutrient removal

Both Chlorella vulgaris Beij and Scenedesmus sp exhibited robust growth in the wastewater medium supplemented with nutrients. Biomass productivity was monitored over the course of the experiment, showing substantial biomass accumulation by both microalgae species. This growth indicates the ability of the microalgae to utilize the nutrients present in the wastewater, thereby reducing nutrient concentrations such as nitrogen and phosphorus through assimilation into their biomass [6].

Organic pollutant removal

The levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in the wastewater were significantly reduced after bioremediation by Chlorella vulgaris Beij and Scenedesmus sp Both microalgae species demonstrated efficient degradation of organic pollutants, leading to a decrease in BOD and COD levels compared

***Corresponding author:** Andressa Reinehr, Department of Environmental Engineering, Faculty of Engineering and Architecture, University of Passo Fundo, Brazil, E-mail: andressa.r.9870@gmail.com

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to the initial untreated wastewater. This suggests that microalgae-mediated bioremediation effectively metabolized organic compounds present in the wastewater, enhancing its quality for potential reuse or safe discharge [7].

Nutrient uptake efficiency

The study also focused on the uptake efficiency of nitrogen and phosphorus by Chlorella vulgaris Beij and Scenedesmus sp Results indicated substantial reductions in total nitrogen (TN) and total phosphorus (TP) concentrations following microalgae treatment. The microalgae efficiently assimilated nitrogen and phosphorus from the wastewater, highlighting their role in nutrient removal and potential application in nutrient recycling strategies.

Lipid content and biofuel potential

Analysis of the lipid content in microalgae biomass revealed promising levels suitable for biofuel production. Chlorella vulgaris Beij and Scenedesmus sp accumulated lipids during wastewater treatment, indicating their potential as feedstock for biodiesel or other biofuel production processes. This dual benefit of wastewater treatment and biomass valorization underscores the economic and environmental sustainability of microalgae-based bioremediation strategies. The results demonstrate the efficacy of Chlorella vulgaris Beij and Scenedesmus sp in bio remediating basil pesto sauce manufacturing wastewater, effectively reducing BOD, COD, TN, and TP levels. The findings align with previous research indicating that microalgae can serve as efficient biological agents for wastewater treatment due to their rapid growth, high nutrient uptake capacity, and ability to metabolize organic pollutants. Moreover, the potential for lipid accumulation in microalgae biomass enhances the economic viability of bioremediation processes by providing a valuable resource for biofuel production. This dual-purpose approach aligns with sustainability goals by reducing wastewater pollution while simultaneously generating renewable energy resources. Challenges such as optimizing growth conditions, scaling up operations, and addressing seasonal variations in wastewater composition remain critical for practical application in industrial settings. Future research should focus on addressing these challenges, exploring additional benefits of microalgae-based bioremediation, and integrating advanced technologies to enhance process efficiency and sustainability. In conclusion, Chlorella vulgaris Beij and Scenedesmus sp represent promising candidates for bioremediation of basil pesto sauce manufacturing wastewater, offering effective pollutant removal and potential resource recovery. Continued research and development in this area are essential to advance microalgae-based bioremediation as a viable solution for sustainable wastewater treatment in food processing industries [8-12].

Conclusion

This study demonstrates the potential of Chlorella vulgaris Beij and Scenedesmus sp in bioremediating wastewater generated from basil pesto sauce manufacturing, highlighting their effectiveness in reducing organic pollutants, nitrogen compounds, and phosphates. The findings underscore the feasibility of using microalgae for sustainable and environmentally friendly treatment of industrial effluents, addressing both water quality concerns and potential resource recovery. Pollutant Removal Efficiency: Both Chlorella vulgaris Beij and Scenedesmus sp exhibited robust capabilities in reducing biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in the wastewater. This indicates their ability to metabolize organic pollutants effectively, enhancing water quality standards for safe discharge or reuse. Biomass Valorization: Analysis of microalgae biomass revealed substantial lipid content, suggesting potential applications in biofuel production. The accumulation of lipids during wastewater treatment highlights the dual benefit of bioremediation processes, contributing to renewable energy resources while treating wastewater. Future research directions should focus on optimizing growth conditions, scaling up operations to industrial levels, and conducting life cycle assessments to evaluate the overall environmental footprint and economic feasibility of microalgae-based bioremediation systems. Additionally, exploring synergistic approaches, such as combined treatments with other microorganisms or advanced technologies like photobioreactors, could further enhance treatment efficiencies and broaden applicability across diverse industrial sectors. In conclusion, Chlorella vulgaris Beij and Scenedesmus sp emerge as promising candidates for bioremediating basil pesto sauce manufacturing wastewater, offering effective pollutant removal, nutrient recycling, and potential biofuel production.

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